



One size does not fit all: Natural infrastructure investments within the Latin American Water Funds Partnership



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ARTICLE INFO

Article history:

Received 26 February 2015

Received in revised form

24 November 2015

Accepted 17 December 2015

Keywords:

Payment for watershed services
Investment in watershed services
Water Funds
Watershed conservation
Source water protection
Ecosystem services

ABSTRACT

Water funds seek to promote long-term watershed conservation with multiple benefits for biodiversity and human well-being. This approach has grown rapidly, particularly in Latin America where more than 30 water funds were in operation or development by 2014. To meet the need for evidence to guide ongoing decisions, we assessed the goals and strategies of 16 programs that were operating in 2013–2014 in association with the Latin American Water Funds Partnership. Our findings underscore the diversity within this approach to investment in watershed services. The various financial, governance, and management mechanisms adopted by these programs reflected their distinct biophysical, socio-economic, and political contexts. All 16 water funds aimed to secure water quality (15/16) and/or quantity (including the timing of flows) (14/16). The majority of programs also explicitly strived for co-benefits to local livelihoods (9/16) and biodiversity (11/16). Public funding secured through legislation provided the most funding to date, but private, NGO, and development bank source were also important for some programs. While programs have actively engaged rural land stewards, this stakeholder group was represented on governance boards in just 4 of 16 funds. Additionally, while the majority of water funds with activities on the ground (13/16) reported biophysical and social impact monitoring (8/16), many faced significant logistical, technical, and funding challenges to its implementation. We recommend greater inclusion of rural land stewards on governance boards, increased engagement of the private sector, and a sustained commitment to an evidence-based approach to increase the likelihood that programs will attain their goals.

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1. Introduction

Investments in Watershed Services (hereafter IWS) represent a rapidly growing policy and finance mechanism worldwide that engages urban and rural communities to address water security challenges (Porrás et al., 2008; Southgate and Wunder, 2009; Bennett et al., 2013, 2014). Such initiatives aim to protect or restore hydrologic services, such as flow and sediment regulation, through investments in ‘natural infrastructure’, including protection or restoration of native ecosystems, agricultural best management practices, and other terrestrial conservation practices (Calvache et al., 2012; Gartner et al., 2013). In practice, many IWS programs also strive to present ‘win-win’ opportunities for conservation and human well-being (Muradian et al., 2013; Ingram et al., 2014).

The number of IWS programs has grown dramatically over the past two decades, demonstrating the expanding appeal of using natural infrastructure to help secure water for people and nature (Bennett and Carrol, 2014). In a recent global inventory, 345 active programs were tracked in 2013, with total investment reaching an estimated \$9.6 billion and covering activities on 365 million hectares (Bennett and Carrol, 2014). Linked to this growth in IWS are rising expectations about what such watershed conservation can achieve as well as discussions about how to replicate and scale up IWS for greater water security and environmental and social co-benefits (Bennett and Carrol, 2014).

However, despite the potential significance of IWS initiatives for the well-being of millions of urban and rural residents, only limited empirical research has considered how these programs work in practice (Bennett et al., 2013; Goldman-Benner et al., 2012; McDonald and Shemie, 2014). This situation hinders the use of real-world experience to inform the evolution of existing programs, the design of new programs, and the identification of the most suitable contexts for IWS given biophysical, economic, or institutional constraints (Wunder, 2013). Additional practical research can help set the stage for evidence-based planning and evaluation that ensures investments achieve program objectives (Porrás et al., 2013; Ferraro et al., 2012; Kroeger, 2013; Naem et al., 2015).

Water funds are a subset of IWS that link downstream beneficiaries to upstream land stewards through a sustainable institutional mechanism (Goldman-Benner et al., 2013, 2012; Raes et al., 2012; Kauffman, 2014). Water funds share three primary organizational components: a *funding* mechanism to collect and provide resources for watershed conservation, a *governance* mechanism for joint planning and decision-making, and a *watershed management mechanism* to carry out funded conservation and management activities. Water funds often seek to adopt a science-based approach to improve the impact and cost effectiveness of watershed interventions. This includes the use of ecosystem service models for targeting and planning, as well as efforts to monitor and evaluate program outcomes in terms of biodiversity, ecosystem services, and human well-being (Calvache et al., 2012; Higgins and Zimmerling, 2013).

Building upon the first water fund launched in 2000 in Quito, Ecuador (Echavarría et al., 2004), the Latin American Water Funds Partnership (LAWFP) now provides support for 16 operational water funds across six countries, with over 20 more funds in development phases. Launched in 2011 by The Nature Conservancy (TNC), the FEMSA Foundation, the Inter-American Development Bank (IDB), and the Global Environment Facility (GEF), the LAWFP is a technical and financial support mechanism for creating and strengthening water funds across Latin America. The programs included in this paper are those that have received support from the LAWFP (see Supplementary Information 1 and 2 for the role of the LAWFP, TNC, and the authors of this paper in the water funds surveyed). This group includes initiatives that do not explicitly self-identify as a water fund *per se*; however, they possess the

essential features listed above and are part of the LAWFP. We examined this group to gain practical insight into how water funds work, including similarities and differences across diverse implementation contexts. We report findings focused on the following research questions:

1. What biophysical and socio-economic objectives do water funds pursue, and how are they monitoring their progress?
2. How are water funds structured to achieve these objectives in terms of (i) funding mechanisms, (ii) governance mechanisms, and (iii) land use, management, and stakeholder activities?
3. Which funding and governance mechanisms have been most successful thus far in securing resources and implementing watershed conservation and management activities?

Our systematic analysis of the current state of operational water funds supported by the LAWFP addresses the need to better document and analyze IWS institutional development (Brockington, 2011; Wunder, 2013), and it offers empirically supported insights to researchers, practitioners, investors, land stewards and other stakeholders about the possibly generalizable institutional approaches for IWS. In this, we aim to identify components that will likely enhance the effectiveness, sustainability, replicability, and scalability of these institutions to achieve conservation and human well-being objectives.

2. Methods

We compiled information on all 16 operating water funds supported by the LAWFP through a structured survey with key water fund representatives (Supplementary Information 3). Additional water funds and similar programs exist in the region but were not surveyed, including FORAGUA in Loja, Ecuador, several Bolivian funds, and many programs in Brazil directly supported by the National Water Agency (Bennett and Carrol, 2014; Raes et al., 2012; Kauffman, 2014). However, our focus on LAWFP facilitated a systematic and detailed inquiry into the similarities and differences across multiple manifestations of the water fund concept. Our sample included 5 programs in Brazil (the Extrema and PCJ projects were grouped as the São Paulo water fund due to shared funding), 3 in Ecuador, 3 in Colombia, 1 in Peru, 2 in the Dominican Republic, and 2 in Mexico (Table 1; Fig. 1). We term all of these programs ‘water funds’ given their support by the LAWFP, despite the fact that the Brazil programs do not specifically refer to themselves as water funds. We defined operational programs as those structured with a known contract or other legal document. At the time of the survey (May 2014), three of the 16 had not yet begun conservation activities on the ground (Table 1). Thirteen of the 16 had established a Board of Directors (hereafter Board) or Project Management Units (hereafter PMUs) in the case of the Brazilian programs, while the final three were in the process of finalizing membership (Table 1). The water funds with an established Board and those with activities on the ground were the same, with the exceptions of Cuenca Verde in Medellín, Colombia which had a Board but no activities (activities began at the end of 2014 after completion of our survey), and Fondo Semilla de Agua in Chiapas, Mexico which had no Board but did have several pilot projects.

Prior engagement with several of these water funds formed the basis for an initial set of survey questions, which we then refined to address our research questions. We distributed the survey to key representatives of each water fund who possessed direct knowledge of objectives, finances, governance, activities, and monitoring. We subsequently interviewed respondents between November 2013 and May 2014. We posed both open-ended

Table 1

The 16 water funds surveyed along with their status at the time of the survey.

Fund Name	Abbreviation	Start Date	Location	Ecosystem targeted	Formalized Board or Project Management Unit	Project Status
Movimento Agua por São Paulo	São Paulo	Extrema: 2005 PCJ: 2009	São Paulo and Minas Gerais states (São Paulo Metropolitan Area water supply area), Brazil	Atlantic forest	Yes	Active
Produtores de Água e Floresta, Guandu	Guandu	2009	Rio de Janeiro, Brazil	Atlantic forest	Yes	Active
Projeto Produtor de Água do rio Camboriú	Camboriú	2012	Balneário Camboriú, Brazil	Atlantic forest	Yes	Active
FUNDAGUA	FUNDAGUA	2007	Espírito Santo, Brazil	Atlantic forest	Yes	Active
Projeto Produtor de Água no Pipiripau-DF	Pipiripau	2008	Brasília, Brazil	Savanna (cerrado)	Yes	Active
Fondo para la Protección del Agua	FONAG	2000	Quito, Ecuador	Páramo, Andean montane forest	Yes	Active
Fondo de Páramos Tungurahua y Lucha Contra la Pobreza	Tungurahua	2008	Tungurahua, Ecuador	Páramo, Andean montane forest	Yes	Active
Fondo del Agu Para la Conservación de la Cuenca del Río Paute	FONAPA	2008	Azuay, Cañar, Ecuador	Páramo, Andean montane forest	Yes	Active
Fondo de Agua por la Vida y la Sostenibilidad, Valle del Cauca	FAVS	2009	Cauca Valley, Colombia	Páramo, Andean montane forest	Yes	Active
Cuenca Verde	Cuenca Verde	2013	Medellín, Colombia	Páramo, Andean montane forest, Quercus forest, grasslands	Yes	Design ^a
Agua Somos	Agua Somos	2009	Bogotá, Colombia	Páramo, High Andean forests, fresh water ecosystems	Yes	Active (pilot projects)
Aquafondo	AquaFondo	2010	Lima, Perú	Andean montane forests, Puna grasslands	Yes	Active
Fondo de Agua Metropolitano de Monterrey	Fondo de Agua Metropolitano de Monterrey (FAMM)	2013	Monterrey, Mexico	Tropical dry forest	Yes	Active (pilot projects)
Fondo Semilla de Agua	Chiapas	2014	Chiapas, Mexico	Sub-tropical forest	No	Design ^a
Fondo de Agua Yaque del Norte	Yaque del Norte	2013	Yaque del Norte, DR	Pine and broadleaf forest	No	Design ^a
Fondo de Agua Santo Domingo	Santo Domingo	2013	Santo Domingo, DR	Pine and broadleaf forest	No	Design ^a

^a Note: these funds had not yet implemented activities on the ground at the time of surveying (were in design stage), but have since begun activities.

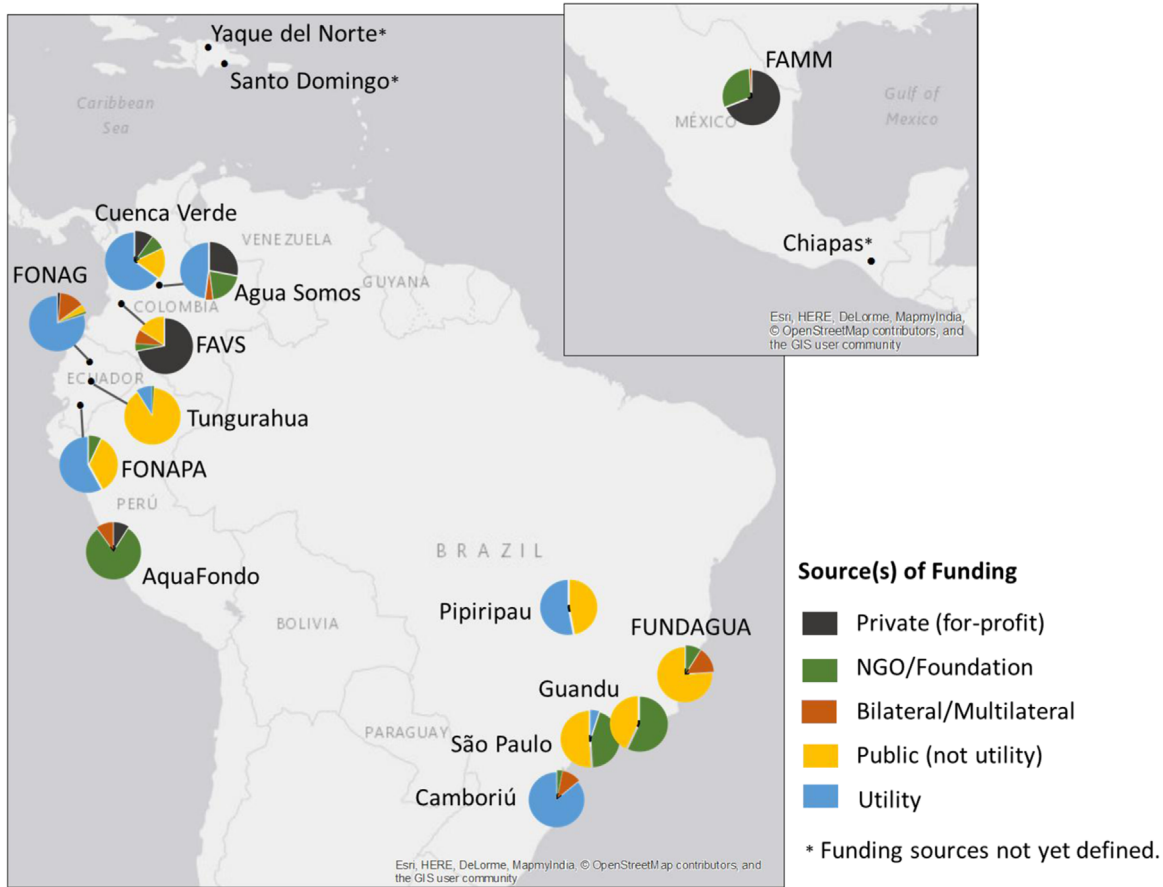


Fig. 1. Location and funding sources of surveyed water funds ($n=16$). Most water funds were financed through a diverse mix of three or more funding sources. Public and utility sources provided the dominant funding for the majority of the surveyed water funds, with strong support by NGOs and the private sector in some cases. Three funds (Fondo Semilla de Agua (Chiapas, Mexico), Yaque del Norte (Dominican Republic), and Santo Domingo (Dominican Republic) had not yet defined funding sources at the time of the survey. Note: FONAPA and Tungurahua also received some support ($< 10\%$ of total budget) from Bilateral/Multilateral sources, but the specific amount was not available so left out of calculations.

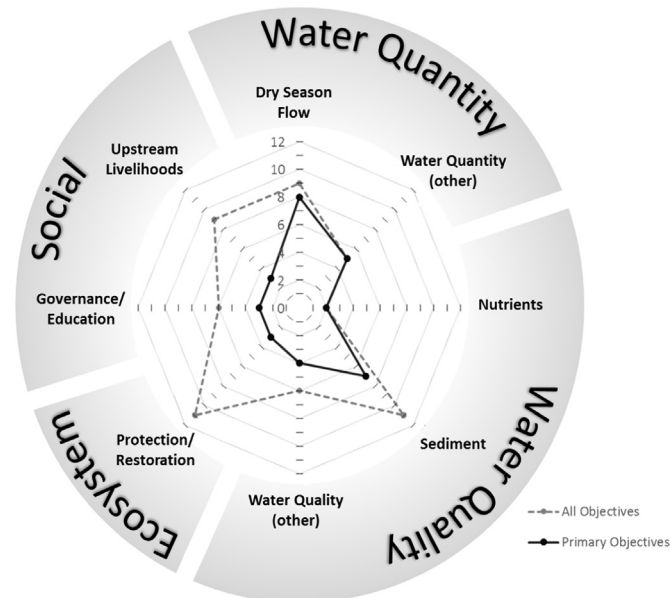


Fig. 2. Stated biophysical and socio-economic objectives of all surveyed water funds ($n=16$). Primary (solid lines) and additional (dashed lines) objectives were identified by the funds, with all those surveyed reporting at least one primary hydrologic objective as well as additional biodiversity or socioeconomic objectives.

questions and those with pre-defined answer choices (Supplementary Information 3).

We asked fund representatives to identify all program objectives targeted by the fund and to further identify those that were primary. We then grouped the stated objectives of all 16 funds into biophysical and socioeconomic categories (Fig. 2). We also recorded the financial and governance structures of the 13 water funds with an established Board or PMU. We analyzed activities of the 13 water funds that had supported watershed conservation or management activities, including the four in pilot stages. Respondents identified all activities supported by the water fund from a list including: protection, assisted revegetation, unassisted revegetation, rural wastewater services, alternative livelihoods, dirt road management, soil conservation, and environmental education. All 16 water funds provided information on existing and planned monitoring. We compared this information against installed or planned monitoring infrastructure, collected monitoring data and monitoring budgets to ensure it accurately reflected current and future monitoring activities, rather than aspirations. We verified all post-interview categorization of responses with fund representatives.

These survey data were complemented with data collected by LAWFP on funding sources and amounts as of December 2013. We classified funding sources into: private (for-profit); NGO/ foundation/civil society (including private foundations); public utilities;

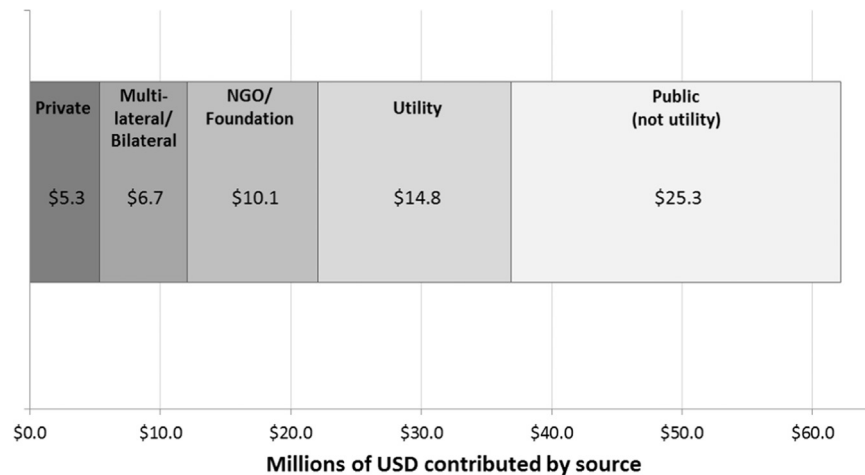


Fig. 3. Total funding (millions of USD) secured by water funds (as of survey date) with established governance Boards or Project Management Units ($n=13$). Water funds with secured funding sources ($n=13$) have obtained approximately 62.2 million USD from diverse sources, with public funding most dominant.

public (not utility); and multilateral/bilateral organizations (Figs. 1 and 3). The distribution of funding sources collected by the partnership was approximate and should be interpreted as self-reported trends, rather than absolute numbers. We further classified the funds according to their dominant model of decision making around how water fund resources are invested. We call these: 1) the *agency model*, 2) the *outsource model*, and 3) the *grant model* (Table 2). In the *outsource model*, a water fund contracts a third party to carry out action plans developed by the water fund. In the *agency model*, the water fund carries out the activities itself. Finally, in the *grant model*, community organizations, indigenous organizations, or municipalities presented proposals to the water fund for review and approval.

Any analysis based primarily on self-reported data is potentially susceptible to bias. However, most of the data we collected and our assessment of it was positive rather than normative in nature and thus subject to bias only from false reporting. To minimize the risk of such bias, key data reported in the surveys and presented in this paper were verified by authors not affiliated with the respective funds or with TNC's water funds strategy (LB, AV, TK). We pursued this project given our interest in expanding the scientific evidence base related to water funds and IWS more broadly. In an effort to be transparent with our roles in these programs, since we as authors include TNC staff and other scientists who have worked with TNC, we provide information on the role of TNC and the authors of this study in the water funds surveyed (Supplementary Information 1 and 2).

3. RESULTS

3.1. What objectives do water funds pursue and how are they monitoring their progress in achieving stated biophysical and socio-economic goals?

Stated objectives of the water funds clustered into 4 broad categories: water quantity (amount and/or timing of flows); water quality (in general or with respect to specific pollutants and/or associated treatment costs); ecosystems (ecosystem/habitat protection or restoration); and social (relating to governance, education, livelihoods, etc.) (Table 2; Fig. 2). The stated primary objectives of surveyed funds were mostly related to water quantity (14/16) and quality (15/16), but many funds also explicitly pursue social and biodiversity objectives.

The specificity of primary objectives related to hydrologic

services varied, as did the articulation of additional biophysical and socio-economic objectives (Table 2; Fig. 2). Securing dry season flows was the most important water quantity objective (primary for 8 of 16 and an objective for one additional program). In addition to dry season flow, 2 recently established water funds in Mexico reported groundwater recharge and flood mitigation as specific water quantity objectives, and 3 programs (including the 2 Dominican water funds) described a general interest in improved water quantity (all categorized as "other water quantity"). In terms of water quality, reducing sediment was a primary objective for 7 of 16 water funds and considered an objective by 4 more. Reducing nutrient concentrations was a primary objective in only 2 cases (in conjunction with sediment reduction in both cases), but an additional 6 water funds reported generally improved water quality as an objective without specifying sediment or nutrient reduction (Fig. 2).

In addition to hydrologic service objectives, 11 of 16 water funds articulated an objective related to conservation or restoration of native ecosystems, but only 3 designated this as primary. In general, conservation and restoration of native ecosystems were viewed as a mechanism to achieve water quality or quantity objectives. Six water funds included land-based targets for the number of hectares restored or protected, and an additional 4 water funds reported specific quantitative targets related to water quality or quantity attributes. We found a trend towards greater articulation of quantitative ecosystem service objectives among the more recently established funds (Table 2).

Explicit socio-economic objectives linked to water quantity or quality were articulated in 9 of 16 cases, but never as a specific quantitative objective. Five water funds (4 in Brazil) explicitly identified a reduction in water treatment costs as the ecosystem service benefit of reduced sediment loads, and 5 reported the objective of reducing risk to water supplies. However, several funds identified beneficiary groups for sediment reduction and baseflow regulation. Of the 11 funds that identified sediment reduction as an objective, 8 explicitly linked sediment reduction to human uses including urban drinking water supplies (6/11), irrigation for large-scale agriculture (1/11), and hydropower (1/11). Dry season stream flow was directly linked to human use in 6 of 9 cases including urban drinking water (4/9), irrigation for large-scale agriculture (1/9), and reducing conflicts between agricultural and urban users (1/9). Specific large beneficiaries such as municipal water companies were identified in 8 of 16 cases (Camboriú; FONAG; FAVS; Cuenca Verde; Agua Somos; Chiapas; FONAPA; Pípiripau), yet respondents largely articulated objectives in terms of

Table 2

Summary of water fund objectives, financial mechanisms, institutional structures, activities, and compensation strategies.
 Bold text denotes the objectives reported as primary.

Water Fund	Biophysical objectives ^a	Socio-economic objectives ^a	Quantitative targets?	Funding mechanisms	Models of decision making and implementation	Activities	Compensation strategy	Who receives compensation
São Paulo (PCJ + Extrema)	Sediment reduction; Dry Season flow	Improve water policy and governance; Environmental education; Reduce treatment costs (Extrema); Improve livelihoods (Extrema)	Land-use targets	<i>PCJ:</i> Donations outside board; Fundraising from within board; PCJ water user fees <i>Extrema:</i> Donations outside board; Taxes; PCJ water user fees; Environmental compensation from State Environmental Agency	<i>PCJ:</i> Outsource (third party implements) <i>Extrema</i> Agency	<i>PCJ:</i> Assisted revegetation; Unassisted revegetation; Protection; Soil conservation; <i>Extrema:</i> Assisted revegetation; Protection; Unassisted revegetation; Soil conservation; Dirt road management; Environmental education; Rural sanitation	Cash payments and project pays for and implements activities	Rural landowners
Guandu	Sediment reduction; Nutrient reduction; Dry season flow; Maintain fish assemblages; Restore forest connectivity	Reduce treatment costs; Water supply risk mitigation; Improve income of upstream landowners; Governance	Reduce dissolved solids below 500 mg/L and turbidity below 100 UNT (Brazilian water supply standards)	Water user fees; Donations outside of board; Environmental compensation from State Environmental Agency	Grant; Outsource (NGO implements)	Protection; Assisted revegetation; Unassisted revegetation; Rural wastewater services; Environmental education; Capacity building	Cash payments and project pays for and implements activities	Rural landowners
Camboriú	Sediment reduction; Flow regulation; Increase forest cover	Reduce treatment costs (related to sediment)	Land-use targets	Donations outside of board members; Designations by board members (primary EMASA)	Outsource (TNC implements)	Protection; Assisted revegetation; Dirt road maintenance; Soil conservation	Cash payments and project pays for and implements activities	Rural landowners
FUNDAGUA	Sediment reduction; Flow regulation; Increase forest cover	Increase small farmer income through PES; Governance	Land-use targets	Oil exploitation royalties; Hydroelectric offsets	Outsource (third party implements)	Assisted revegetation; Unassisted revegetation; Livestock management; Agricultural water use efficiency; Rural wastewater; Dirt road management; Environmental education; Alternative livelihoods	Cash payment and project pays for and implements activities	Rural landowners
Pipiripau	Dry season flow; Sediment reduction	Reduce treatment costs for water company (sediment); Avoid conflict between urban and cattle	Land-use targets	Designations by board members	Outsource (NGOs and government agencies implement)	Assisted revegetation; Soil conservation; Unassisted revegetation; Livestock	Cash payments and project pays for and implements activities	Rural landowners

		ranchers (related to dry season flow					management; Agricultural water use efficiency; Dirt road management Protection (park guard to reduce grazing and burning); Unassisted revegetation; Assisted revegetation; Environmental education; Training and capacity building; Alternative livelihoods	In-kind compensation; Conservation agreements; Direct conservation interventions; Park guards	Rural communities and private landowners
FONAG	Recuperation of water quality for human consumption; Dry season flow; Terrestrial and freshwater ecosystem integrity	Reduce operational and financial risks related to water availability during the dry season	Land-use targets	Percentage of water company income established by Municipal ordinance; Donations outside of board members; Annual designations by board members; Interest generated by endowment	Agency; Outsource (some third party implementation); Grant				
Tungurahua	Conserve watershed for water quality and water quantity (dry season)	Guarantee quality of life for indigenous and other rural communities	None	Annual budget designations by board members; Donations outside of board members; Interest generated by endowment	Grant		Protection; Agricultural livelihoods; Unassisted revegetation; Assisted revegetation; Environmental education	In-kind compensation; Conservation agreements; Direct conservation interventions	Rural landowners and communities; local NGOs
FONAPA	Conserve watershed for water quality and water quantity (dry season)	No explicit socio-economic objective identified beyond water quality and quantity	None	Annual budget designations by board members; Interest generated by endowment; Designations established by municipal ordinances	Outsource; Grant		Protection (park guards to reduce deforestation, burning and grazing); Livestock management	In-kind compensation; Conservation agreements; Community park guards	Rural landowners and communities; Park guards; Municipalities
FAVS	Dry season flow; Terrestrial and aquatic biodiversity; Sediment retention	Improve livelihoods and quality of life of upstream communities; Reduce operational and financial risks related to water availability for irrigation in dry season (for sugar)	Land-use targets	Donations outside of board members; Annual budget designations from board members (sugar cane primarily)	Grant		Protection; Unassisted revegetation; Silvopastoral systems; Environmental education; Training and capacity building; Alternative livelihoods(e.g. agroforestry); should be spaced as two activities degraded forest; Strengthening of local organizations	In-kind compensation	Rural landowners and communities; iRver associations
Cuenca Verde	Reduce sediment; Reduce nitrogen	Reduce risks to public health and risks of increased treatment costs due to deteriorating water quality in reservoirs; Improve livelihoods of upstream landowners	20% reduction in sediment; 12% reduction in nitrogen	Donations outside of board members; Annual designations from board members; Interest generated by endowment	Outsource		No activities at time of survey ^b	Planned: In-kind compensation; Conservation easements; Potential for PES	Rural private landowners
Agua Somos	Reduce sediment;	Reduce treatment costs	Reduce sediment by	Donations outside of	Outsource		Pilot projects ^a :	Planned:	Future: upstream

Table 2 (continued)

Water Fund	Biophysical objectives ^a	Socio-economic objectives ^a	Quantitative targets?	Funding mechanisms	Models of decision making and implementation	Activities	Compensation strategy	Who receives compensation
	Biodiversity	(related to sediment); Improve livelihoods of upstream communities	2 million tons/year	board members; Annual budget designations from board members		Assisted revegetation; training	In-kind compensation; Potential for PES	landowners in buffer zone
AquaFondo	Improve management and conservation in Lima's watersheds; Improve water quality (general); Increase water quantity (general)	Create new water culture; Promote integrated water resource management and improved governance; Enable strategic alliances	None	Donations outside of board members; Annual Budget designations from board members	Agency; Outsource (local NGOS TBD)	Protection; Environmental Education; Agricultural water use efficiency; Restoration of ancient infiltration channels; Water resource council support	Community and local agreements; Donor carries out particular project (e.g. drip irrigation); Plan to use in-kind compensation	Rural communities
FAMM	Improve regulation and flows (reduce peak flows); Improve infiltration to enhance ground water recharge	Create new water culture; Develop capacity in environmental resource management	Reduce flash flooding by up to 750 m ³ /sec; Improve the quantity of water available for infiltration by 20%	Multi-annual designations from board members; Donations from outside board members	Outsource (NGO)	Pilot projects: Dry forest conservation	Cash payments	Rural landowners in National Park
Chiapas	Improve sediment retention; Increase water regulation; Increase ground-water recharge	Climate change adaptation	None	Not fully defined	Outsource (not yet defined, likely NGO)	Pilot projects: Living sediment barriers; Training; Protection	Not yet defined	Not yet defined
Yaque del Norte	Increase water flow; Sediment reduction; Increase water quality (general); Increase vegetation cover	Improve local livelihoods	None currently, but will be established	Not fully defined	Outsource (not yet defined, likely NGO)	No activities at the time of survey ^b	In-kind compensation	Not yet defined
Santo Domingo	Increase water flow; Sediment reduction; Improve water quality (general); Increase vegetation cover	Improve local livelihoods	None currently, but will be established	Not fully defined	Outsource (not yet defined, likely NGO)	No activities at time of survey ^b	In-kind compensation	Not yet defined

^a Protection efforts in páramo areas in Chingaza National Park have become the dominant activity for Agua Somos since the time of the survey.

^b Three water funds who were not conducting activities (Santo Domingo, Yaque del Norte, and Cuenca Verde) have since begun activities on the ground. This includes reforestation and shade coffee restoration through the Coca Cola Replenishment Project in The Dominican Republic Funds (Santo Domingo and Yaque del Norte).

multiple beneficiaries across several categories of anthropogenic water use. For example, a primary objective of Cuenca Verde (Medellín, Colombia), Guandu (Rio de Janeiro, Brazil), and FONAG (Quito, Ecuador), is the holistic prevention of further degradation of watersheds, intended to limit threats to water supplies from excess sediments and nutrients and insufficient dry season flow (Table 2).

Beyond socio-economic benefits resulting from increased ecosystem services provision, improving the livelihoods of participating land stewards was the most frequently identified socio-economic objective (identified in 9 of 16 cases, primary in 3 cases). Whether or not improved livelihoods was explicitly stated as an objective, most respondents noted that they perceived benefits to participating landowners from better water supplies, direct payments, in-kind compensation, and/or sustainable development projects. The two Andean water funds with a primary objective related to livelihoods (FAVS and Tungurahua) emphasized that improving livelihoods and human well-being has both social as well as ecological benefits and is viewed as a critical component of achieving sustainable watershed management. Improved watershed management and decision making, including enhanced governance and environmental education, was also an objective in 6 of 16 cases (Table 2; Fig. 2).

3.2. How are water funds monitoring progress toward achieving objectives?

All program respondents emphasized the importance of assessing progress toward objectives in terms of observed, attributable changes following fund activities, but water funds differed in the degree of rigor of existing and planned monitoring and evaluation programs. All 13 water funds that were currently conducting activities reported compliance and implementation monitoring to assess whether supported activities had actually occurred. At the time of the survey, the 10 water funds with activities on the ground beyond small pilot projects involved 12–2,196 families/landowners (median=306) and influenced between 20 and 92,700 ha (median= 4652 ha) through some type of protection or restoration activity (Table 3).

Eight water funds engaged in some form of impact monitoring, defined as measuring relevant biophysical or socioeconomic variables plausibly responsive to activities. Just two of the 10 program with activities on the ground beyond small pilots were not conducting monitoring. Moreover, all but one of the programs not monitoring currently ($n=8$) indicated that planning for impact monitoring is ongoing, including 3 water funds that anticipated monitoring alongside the start of activities (Table 3).

Streamflow measurement was most common among water funds conducting impact monitoring (7 of 8; data typically collected at sub-hourly frequency), and corresponded to objectives concerning water quantity (Fig. 5). Three water funds conducting activities with water quantity objectives were not monitoring stream discharge. Fewer water funds monitored sediment levels (6 of 8), despite the frequency of sediment control as a primary stated goal (Fig. 5). In 3 cases, sediment level monitoring was sub-hourly, but measurement was relatively infrequent in the remaining programs (monthly to twice a year; Supplementary Information 4). Independently collected water quality and quantity data were reportedly available at downstream points of use in several instances. However, with the exception of one fund (Camboriú), the quality and frequency of available data where benefits would be realized (e.g., intake points) was unclear, as were plans to explicitly link monitoring data to program outcomes.

In addition to financial constraints, program managers identified the challenge of defining appropriate measurement controls and the scarcity of baseline data as major impediments to assessing

impacts. Six of 7 water funds conducting hydrologic impact monitoring indicated access to baseline water quantity or water quality data, but the duration, frequency and quality of these data were often poor or inconsistent. At the time of the survey, 5 funds had established control-impact designs with at least a short baseline period in order to begin generating data to facilitate improved future performance assessment.

Socio-economic impact monitoring was gaining momentum, but still lagged behind measures of biophysical attributes and program objectives (Fig. 5; Table 3). Although the majority of water funds track the number of participating families and payments disbursed, measurements of the benefits and risks of participation relative to a baseline were uncommon (e.g., positive and negative outcomes related to financial, social, and human capital). Four water funds reported beginning to monitor upstream social conditions: FAVS, for which improved livelihoods were a primary objective, and AquaFondo (Peru), as well as two Brazilian funds (Camboriú and São Paulo).

3.3. How are water funds structured to achieve these objectives?

3.3.1. Funding mechanisms

The total funding generated over the 16 water funds surveyed was approximately 62.2 million USD (Fig. 3) at the time of the survey, ranging from approximately \$800,000 USD (AquaFondo and Agua Somos) to \$21.5 million USD (FUNDAGUA) (Table 3). Pooled over all water funds surveyed, funding came from a variety of sources, including private companies (8.6%), non-governmental organizations (NGOs) and foundations (16.2%), and bilateral and multilateral institutions (including the IDB and the GEF) (10.8%) (Fig. 3). However, public funding from municipal utilities (23.7%) and other public sources (including government and watershed committees) (40.7%) remained dominant (Fig. 3). Within individual funds, municipal utilities and other public sources were the most important contributors in 6 and 3 cases (out of 13), respectively, and all but 2 water funds received some public support (Fig. 1). In the case of watershed committees, which formed an important part of two water funds (São Paulo and Guandu), funding was collected from the main large water users in the watershed, rather than all end users.

Private funding represented less than 10% of funding overall (Fig. 3), but 6 water funds obtained some funding from private for-profit sources and 2 reported private funding as the most abundant source to date (Fig. 1). The Monterrey water fund (Mexico) has attracted substantial private capital from multiple private companies including CEMEX (a cement company), FEMSA, Heineken, and ARCA Continental (bottling companies), among others. In addition, FAVS (Cauca Valley, Colombia) is largely supported by the sugar cane sector. Cuenca Verde (Medellín, Colombia) and Agua Somos (Bogotá, Colombia) also received a substantial portion of funding from private investors (Grupo Nutresa and Gaseosas Posada Tobón in the case of Cuenca Verde and Bavaria in the case of Agua Somos) (Fig. 1). We note that private (for-profit) sources are included here regardless of the motivation of donation, but private foundations (including FEMSA foundation) are classified under philanthropic sources (NGO/foundation). We also note that many large water users in Latin America, such as utilities and hydropower providers, operate as public rather than private entities.

Despite all funds receiving some support from bilateral or multilateral organizations (commonly through IDB-GEF, but also German Corporation for International Cooperation, GIZ, and the United States Agency for International Development, USAID) or NGOs and private foundations, only 2 reported NGOs/foundations as primary funding sources (Fig. 1). In some cases, funding sources changed through time. An example is the Guandu water fund, which was initiated by a private foundation before shifting to the

Table 3
Indicators of programmatic progress for the 16 operational water funds.

Water Fund	Area of land management change (or protection)	Number of people participating	Monitoring	Prioritization mechanism/evidence base?	Total amount of funding obtained (millions USD)	Funding contractually guaranteed?	Board/Project Management Unit composition (* decision power)
São Paulo (PCJ + Extrema)	PCJ: 68 ha reforestation; 321 ha remnant restoration; 100 ha soil conservation; Extrema: 342 ha reforestation; 840 ha remnant restoration; 2456 ha soil conservation	210 landowners	PCJ: Compliance; Flow; Water quality (multiple parameters); 'Upstream' socio-economic (baseline); Extrema: Compliance; Flow; Sediment; Water quality (multiple parameters); 'Upstream' socio-economic (baseline)	Focused on riparian areas, degraded roads, and degraded pasture areas; Currently have a priority map derived from InVEST sediment modeling	PCJ: 4.6 million USD; Extrema: 3.5 million USD (based on \$500,000 annual budget)	PCJ: No; Extrema: YES 30% guaranteed by municipal law	PCJ: Public (7); Civil Society (5);; Extrema: Public (2); Civil Society (2)*equal vote
Guandu	3095 ha protection; 492 ha restoration	62 landowners	Compliance; Flow; Sediment; Water quality (multiple parameters)	InVEST sediment retention and field studies of degradation	4.9 million USD	Yes – 2 watershed committee resolutions; allocated 1.2 million to Guandu PES fund and 3.5% from collected water fees (20% of current resources)	Public (4); Civil Society (2)
Camboriú	38 ha reforestation; 185 ha protection; 318 ha remnant restoration;	12 landowners	Compliance; Flow; Sediment; Water quality (multiple parameters); 'Upstream' socio-economic baseline	InVEST; SWAT (sediment retention)	1.9 million USD	Yes. 1% of EMASA revenue guaranteed by law (~\$175,000/year) for PES payments	Public (8); Civil Society (1) equal vote
FUNDAGUA	360 ha reforestation; 3957 protection	459 landowners	Compliance; Forest cover	Multicriteria analysis to identify high risk erosion sites and lack of forest cover	21.5 million USD	Yes, by law	Public (6); Civil Society (2) equal vote
Pipiripau	103 ha reforestation; 157 ha forest protection; 562 ha soil conservation	33 landowners	Compliance; Flow, Water quality (multiple parameters)	InVEST, MUSLE and ARA tool for sediment; Field studies of erosion; Feasibility	2.4 million USD	No	Public (8); Civil Society (3) equal vote
FONAG	60,000 ha protected areas (in past); 30,000 ha control and surveillance; 2,700 ha restoration	400 families	Compliance; Ecosystem integrity (freshwater and terrestrial); Water quality (nutrients, bacteria, TSS); Flow	Water company pointed to where most important water problems were; WEAP hydro model; Field water quality and quantity studies. quality; Social outcomes; feasibility; Planning to use RIOS	13.3 million USD ^a	Yes – 2% of income of water company guaranteed by Municipal ordinance	Public (2); Civil Society (2); Private (2) based on financial contribution
Tungurahua	700 ha public protected areas; 24,000 ha conservation agreements in communal areas	2196 families	Community-based compliance; Flow and water quality in planning stages	Indigenous communities; social prioritization	2.9 million USD ^a	No	Public (5); Civil Society (3) equal vote

FONAPA	109 ha conservation agreements and restoration in public and private areas; 33,000 hectares control and surveillance	212 families	Compliance; Flow and water quality in planning stages	Multi-criteria analysis	1.0 million USD ^a	Yes – 3 recently passed municipal ordinances (future funding source)	Public (4);Academic (1); Civil Society (2) equal vote
FAVS	3000 ha of protection, reforestation, silvopastoral, agroforestry systems	497 families	Compliance; Sediment; Flow; Water quality (bacteria, TSS, nutrients); Stream characteristic; 'Upstream' socio-economic	SWAT (high sediment areas); RIOS based prioritization; Stakeholder maps	3.5 million USD	No	Pubic (1); Private (3); Civil Society (2) equal vote
Cuenca Verde	Pilot projects	NA	None yet, but planned (including hydrologic an socio-economic)	SWAT (erosion control); InVEST (nutrients); Field studies of sediment and nitrogen; Biodiversity hot spots	1.3 million USD	Yes – 20% guaranteed for 5 years (EPM and envt'l authorities)	Public (4);Private (3); Civil Society (1) based on number of seats
Agua Somos	3 ha	NA	None yet, but planned (including hydrologic an socio-economic)	SWAT, FIESTA, InVEST (erosion control)	0.8 million USD	No	Public (1); Private (1); Civil Society (2) equal vote
AquaFondo	20 ha	300 including recent pilot project; 1000 students in envt'l education	Flow; Upstream community socio-economic	Prioritization primarily through community interest in pilot project: Areas of hydrologic importance (e.g. high elevation puna grasslands)	0.8 million USD	No	Private(1); Civil Society (4); Academic (1) equal vote
FAMM	Small pilot projects to date.	NA	None yet, but planned (including hydrologic and socio-economic)	Focus on National Park which is main water source; RIOS	2.9 million USD	Not yet	Civil Society (1); Private (9) equal vote
Chiapas	NA	NA	None yet	SWAT, InVEST	N/A	N/A	Not yet defined
Yaque del Norte	NA	NA	Monitoring protocols in design (hydrologic and socio-economic)	In process; expert advice for initial prioritization then, using RIOS and InVEST for water quantity; also prioritizing for water quality	N/A	N/A	Not yet defined
Santo Domingo	NA	NA	Monitoring protocols in design (hydrologic and socio-economic)	In process; expert advice for initial prioritization then, using RIOS and InVEST for water quantity; also prioritizing for water quality	N/A	N/A	Not yet defined
Summary	169,369 ha	4944 landowners/families	Flow (7); Sediment (6); Nutrients (3); Biodiversity (3); Upstream socio-economic (4)	Empirical studies (5); Hydrologic modeling (12); Social and community interest (4); Multi-criteria analysis (3); Biodiversity (2)	62.2 million USD	Contractually guaranteed (6)	See Fig. 4

^a With the exception of FONAG (where info from one outside member was available), only funding from board members was included in Ecuador water funds as information on other (much less significant) sources of funding was not available.

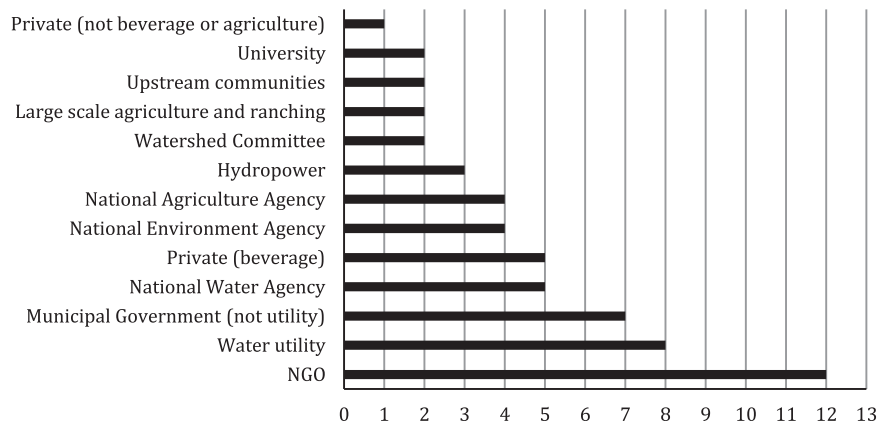


Fig. 4. Representation of stakeholder groups on Boards and Project Management Units (PMUs) among water funds with established Boards and PMUs ($n=13$). Bars represent number of funds with representation of a given stakeholder group. Water fund Boards and Project Management Units include diverse stakeholders groups, but private and upstream communities are under-represented.

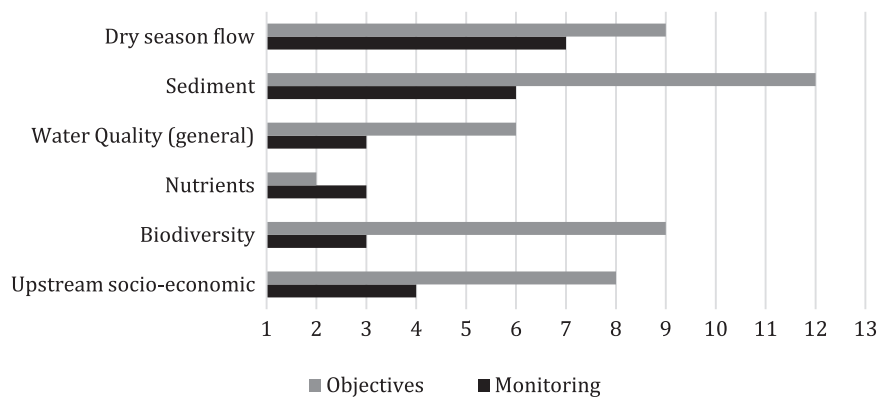


Fig. 5. Number of programs monitoring objectives (black bar) versus number of programs with a stated objective (gray bar). For most objectives (with nutrients being the only exception), funds are not always monitoring progress toward all of their stated objectives. Note: one water fund (FAVS) is monitoring nutrients as part of their overall water quality monitoring protocol, despite this not being a specific objective of the fund.

current support from a watershed committee.

Operational financial management also varied among the surveyed water funds. Previous studies have characterized water funds as involving an endowed trust (Goldman-Benner et al., 2012; Kauffman, 2014), but only 3 Ecuadorian programs reported funds being managed in this way. However, the 2 other Andean water funds either managed resources in a single account with a back up trust fund or managed funds through an existing environmental fund. Additionally, 4 of the emerging water funds in Mexico and the Dominican Republic plan to utilize the trust fund model, although it remains to be seen whether this will be the primary source of funding for their operations in the coming years. In contrast, financial resources of water funds in Brazil were typically managed by members of the PMUs in line with guidance provided by watershed committees (Table 2).

Water funds with established Boards varied in terms of long-term funding security, with 7 of 13 relying primarily on voluntary contributions from Board members and PMUs or from outside sources. However, 7 of 13 reported that some portion of funding was contractually or legislatively guaranteed (Table 3). Legal means to secure funding included municipal ordinances requiring reinvestment of a portion of water utility profits in watershed management; national laws channeling environmental offsets to water funds; and laws requiring that water user fees (collected from water utilities and large companies) be invested in conservation. For example, the Water Producer Program, first

developed by the Brazilian National Water Agency (ANA) capitalizes on a Brazilian law requiring that watershed committee user fees (currently from large water users) be invested in watershed conservation. Also in Brazil, in another example, the Extrema Municipality passed the first Brazilian law allowing municipal funds to be used to support payments to rural landowners for conservation and restoration. In other cases, funding was not contractually guaranteed, but a history of strong commitment by the principal investors and strong fundraising capacity by the water fund manager offered some certainty. For example, Tungurahua (Ecuador) and FAVS (Valle del Cauca, Colombia) are two well-established programs operating with this model (though Tungurahua did obtain approximately \$60,000 USD in annual interest from a trust fund) (Table 3). In the case of FAMM Monterrey (Mexico), the level of water fund investment determined Board membership, which, according to managers, inspired and recognized long-term commitment.

3.3.2. Governance mechanisms

In addition to providing important financial resources, water fund Board members or PMU member organizations decide where and how to invest financial and technical resources to achieve program goals. Thirteen of the 16 water funds included in the survey have established Boards or PMUs while 3 (Yaque del Norte, Chiapas, and Santo Domingo) were still in the process of formalization at the time of the survey and are not included in this

discussion.

The process of creating and structuring boards and PMUs varied among funds. In general, board members, including major water users and other key watershed stakeholders, are identified and recruited by the initial promotional group (made up of various entities such as municipalities, TNC, or water companies). Board members are generally expected to provide a financial contribution, but in some cases may provide other kinds of contributions (e.g., office space).

Boards and PMUs ranged from 4 to 12 members (mean=8) (Table 2; Fig. 4). The initial founders typically determined the number of board members, but in some cases there is also a legally established minimum number. It was also common for additional board members to be added over time. At the time of the survey, municipal water utilities were represented on Boards or PMUs in 8 of 13 water funds. Municipal governments (not utilities) participated in 7 of 13 cases (Fig. 4). The Brazilian National Water Agency was active in all 5 water funds in Brazil, but similar national agencies were not involved in other countries. Among private entities, the beverage industry was present in 5 of 13 water fund Boards or PMUs. A commercial agricultural company and a cement company were also represented. Hydropower providers participated on the Boards of only 3 Ecuadorian water funds, despite the occurrence of hydropower generation in basins of 10 of the 13 water funds. Participating land stewards (labeled as 'upstream communities' in Fig. 4) had Board representation in the 2 water funds with a primary goal of improving livelihoods in upstream communities, with 2 community-based river associations active in FAVS (Colombia) and indigenous associations on the Tungurahua (Ecuador) Board (Table 3). In Guandu (Rio de Janeiro, Brazil) and PCJ (São Paulo, Brazil), civil society groups representing upstream landowners were present on watershed committees.

Decisions of the Board or PMU included approval of annual budgets, annual operation plans, watershed management and conservation plans, and selection of a technical secretariat. Water funds executed watershed management and conservation activities through one or more of the following models of decision making and project implementation: 1) internal planning and activities contracted to a third party or Board member (*outsourcing model*; 10 of 13 cases), 2) internal planning and direct implementation (*agency model*; 2 of 13), or 3) reviewing and selecting activity plans submitted by third parties or Board members (*grant model*; 4 of 13 cases) (Table 2). In 10 of 13 cases, respondents reported that board or PMU decisions were made by simple majority vote. In the three exceptions, financial contributions determined voting weight (Table 3).

3.3.3. Implemented activities

Thirteen of 16 programs had activities on the ground at the time of the survey (with Yaque del Norte, Santo Domingo, and

Cuenca Verde yet to implement activities). We classified the reported water fund activities into 8 categories (Table 4), with individual programs engaged in 1–8 (mean=4.3). The most common were protection of native terrestrial ecosystems (11 of 13, e.g. increased enforcement patrols in protected areas; fencing to protect existing vegetation) and revegetation (10 using active techniques such as replanting, and 9 adopting passive techniques such as natural regeneration within fenced areas) (Table 2; Table 4). Brazilian Atlantic forest and Andean páramo grasslands were the primary terrestrial ecosystem targets for protection efforts. The two water funds without current native terrestrial ecosystem protection reported future plans for extensive protection efforts. Agua Somos in Bogotá, Colombia anticipated the protection of páramo grasslands in Chingaza National Parks, and Fondo Semilla de Agua in Chiapas, Mexico expected the protection of Reserva de la Biosfera el Triunfo. Water quality and quantity objectives motivated revegetation efforts across locations, but Brazilian water funds engaged more prominently than Andean funds in active planting (partially for forest code compliance reasons). These programs also often incorporated dirt road management and other soil conservation practices (e.g., terracing, ditching, livestock management) (Table 2). Five water funds provided technical training and assistance to rural land stewards for alternative livelihood development (e.g., agroforestry, silvopasture, organic gardens). This agricultural extension activity was motivated either by the direct objective of improved local livelihoods or the expectation that such improvements contribute to achieving hydrologic or biodiversity objectives. For instance, FAVS (Cauca Valley, Colombia) frequently supported the development of silvopastoral systems, agroforestry, and home gardens. Eight of 13 water funds engaged in some form of environmental education (Table 3).

All water funds reported working with local land stewards to carry out some or all of their activities. The 10 water funds with activities on the ground beyond small pilots reported several forms of compensation to landowners, including cash payments and in-kind support such as materials and assistance to carry out conservation practices and livelihood activities (Table 2). In-kind support was more common among Andean water funds ($n=5$), whereas cash payments combined with in-kind support to carry out the conservation activities predominated among Brazilian water funds ($n=5$). In the case of in-kind support, financial resources are provided to the water fund staff or NGO, community, or government implementing organization to support activities such as building fences, home gardens, and agroforestry systems. In the case of direct payment for ecosystem services (PES), payments are distributed to the participating landowner (Table 2). The Brazil PES programs all require a legally binding contract with landowners, which contrasts with other water funds that do not have such legally binding contracts. In Brazil, many programs also

Table 4
Activities supported by water funds (out of $n=13$ funds with activities on the ground).

Category	Examples/Description	Number of water funds
Protection	Increased enforcement patrols in protected areas; Fencing to protect existing vegetation	11
Active revegetation	Active riparian planting, active reforestation;	10
Passive revegetation	Fencing to support natural regeneration of forest or other vegetation	9
Soil and conservation on agricultural lands	Terracing, ditching, livestock management, water use efficiency	5
Environmental education; natural resource governance	Environmental education in schools, workshops on environmental themes, supporting community-based organization	8
Sustainable livelihoods	Agroforestry systems, organic gardens, organic production, silvopastoral	5
Rural wastewater management	Biocombusters	3
Dirt road management	Reducing erosion from dirt roads	5

create jobs in local communities by hiring residents to carry out activities. Emerging water funds in Mexico planned to utilize cash payments, while Dominican Republic water funds expected to utilize in-kind compensation. One fund, FONAG, has also recently implemented conservation on land purchased by the water company, but has hired local community members to work as park guards and to carry out restoration activities.

Water funds were mixed in the extent to which they systematically prioritized the type and location of activities using an evidence-based approach (Table 3). Five (Guandu, FONAG, Extrema, Pipiripau, and AquaFondo) of 16 water funds pointed to completed or on-going empirical studies linking targeted ecosystem services to promoted land uses in similar ecosystems. Several others described assumed or modeled relationships between native vegetation condition and biophysical objectives. Twelve of 16 water funds had conducted some type of hydrologic ecosystem services modeling such as InVEST (Sharp et al., 2014), SWAT (Gassman et al., 2007), or RIOS (Vogl et al., 2015) to prioritize activities or evaluate potential impacts. Modeling efforts also contributed to establishing quantitative targets in two water funds. Andean water funds tended to use multi-criteria analysis including socio-economic, ecological, and political components to prioritize activities, whereas Brazilian initiatives focused on projected ecosystem service impact (Table 2).

3.4. Which types of funding and governance mechanisms have been most successful thus far in obtaining funding and implementing watershed conservation and management activities?

The most effective funding strategy in terms of amount of funding attracted relied on public sources including contributions from utilities, oil and gas royalties, and taxes. Such public sources produced both the majority of the overall funding (public sources, including utilities contributing 62.8% of total funding; Fig. 3) and represented the dominant source of funding for the highest-capitalized funds (e.g. FUNDAGUA, FONAG). The most successful strategy in securing this public funding was through legislation, through, for example, legislation requiring that a portion of utility, municipal, or oil revenue budget be invested in watershed conservation activities (Table 3).

At this time, it is difficult to evaluate how board composition or institutional structures have influenced project outcomes. However, participation by the largest water user(s) has been critical to program establishment. At the time of the survey¹, the lowest amount of funding had been attracted by two of the funds (AquaFondo and Agua Somos) that lacked board membership by major municipal water companies in target watersheds. Moreover, participation by upstream communities and landowners can increase sustainability of the water fund given the greater potential to manage the program adaptively. Representatives from two water funds (Tungurahua and FAVS) with participation by upstream communities identified this involvement as essential to successful engagement with local landowners. These two programs also have the highest number of participating families (2196 and 497 families respectively) and relatively large amounts of funding generated (2.9 million USD and 3.5 million USD respectively).

4. Discussion

Our results demonstrate the institutional heterogeneity within

the water fund approach, revealing diverse program objectives, varied financial and governance mechanisms to achieve these objectives, and a mix of strategies to monitor and evaluate program outcomes. As suggested in prior accounts (Goldman-Benner et al., 2013, 2012; Kauffman, 2014), differing socio-economic and political contexts, including the types of stakeholders involved, have led to multiple viable models for successful water fund establishment and implementation. The following sections relate the specific findings of this study to some of the broader questions faced by the communities engaged with IWS and water funds.

4.1. Water funds promote multiple biophysical and socio-economic objectives

Our results support previous research on IWS in Latin America indicating that water funds often target multiple goals, but that sediment reduction and flow regulation were among the most prominent focal ecosystem services (Porrás et al., 2008; Martín-Ortega, et al., 2013). However, water funds varied substantially in the specificity and types of objectives prioritized, representing a mix of the types of IWS programs proposed in previous accounts (Engel et al., 2008; McAfee and Shapiro, 2010; Muradian et al., 2010; Rosa et al., 2003). Funds that articulated few, well-defined, and quantitative primary ecosystem service objectives ($n=5$) are in line with 'conservation efficiency' PES recommendations (Engel et al., 2008; Wunder, 2008; McAfee and Shapiro, 2010). Other water funds' ($n=2$) primary objectives were to support rural land stewards in joint conservation and development, reflecting the perspective on PES that sees equity and efficiency as inextricably linked (Rosa et al., 2003; Corbera and Pascual, 2012; Kauffman, 2014). Nonetheless, the majority of programs ($n=9$) fell along this spectrum, stating objectives focused on ecosystem services for downstream users alongside the expectation that improved livelihoods and well-being of upstream participant communities are necessary to achieve lasting conservation.

Our finding that many water funds either had explicit 'upstream' social objectives or saw improving livelihoods as necessary to achieve lasting conservation objectives points to the practical importance of incorporating social concerns into program design, whether through explicit or implicit objectives. Several representatives, for example, expressed the idea that "conservation does not work with hunger." Despite arguments that primary social objectives can detract from efficient targeting of investments in ecosystem services (Engel et al., 2008; Kinzing et al. 2011; upstream landowners are unlikely to participate broadly in water fund activities if they do not recognize equitable benefits (Bremer et al., 2014a, Bremer et al. 2014b; Jack et al., 2008). Accordingly, our research supports the idea that efforts to scale up the water fund concept must address the challenges of building social capital with upstream communities and private landowners (Corbera and Pascual, 2012; Rosa et al., 2003). In some cases, such as in-kind support or payments for adoption of agroforestry practices for erosion control and crop production, a single strategy may efficiently accomplish 'upstream' and 'downstream' objectives. In other cases, separate strategies may be needed (e.g. payments for installing riparian buffers for nutrient retention; and provision of home gardening inputs or cash transfers for livelihood improvements).

Our findings also support the idea that IWS and water funds can contribute to biodiversity protection by recruiting novel stakeholders and resources to conservation (Goldman et al., 2008; Reyers et al., 2012; Tallis and Polasky, 2009). However, the specific effects on native flora and fauna will depend on the activities pursued, which our study demonstrates may be quite varied. For example, avoiding the degradation and loss of forests, páramo, and other natural ecosystems is very likely to translate into

¹ Agua Somos has since gained support of the Municipal water company and AquaFondo may receive Municipal water company support in the near future.

biodiversity benefits, whereas the implications of even carefully managed grazing in systems like páramo grasslands (targeted by the majority of Andean funds) are less well understood (Keating, 2007; White, 2013). Accordingly, improved understanding of relationships between land management and ecosystem services and biodiversity remains imperative.

4.2. *Water funds increasingly seek to be evidence-based, but there is not yet clear evidence that water funds are obtaining their objectives*

We found that water funds were responding to growing calls for evidence-based approaches (Higgins and Zimmerling, 2013; Porras et al., 2013), including modeling to prioritize investments, monitoring of program impacts, and adaptive activity management. However, more work is needed to broadly establish analytically rigorous methods for activity prioritization or the identification of control groups, sites, and catchments. In particular, funds wishing to demonstrate impacts and allow economic evaluations must apply an analytically rigorous framework that credibly links specific interventions to target service flows; employ service metrics that are temporally and spatially specific where necessary and that are expressed in benefit-specific terms; implement monitoring based on those service metrics; and use counterfactuals and empirical benefit and valuation functions (Ferraro et al., 2012; Kroeger, 2013). Likewise, in many cases, conservation costs are not clearly integrated into the prioritization mechanism, thus likely reducing the total service gains that could be achieved with available budgets (Kroeger, 2013; Duke et al., 2014; Wünschler et al., 2008; Murdoch et al., 2007). However, incorporation of management costs into prioritization mechanisms is increasing with tools like RIOS (Vogl et al., 2015).

As with many PES programs more broadly (Muradian et al., 2010; Farley et al., 2013; Bennett and Carrol, 2014), the majority of water funds based land-management prescriptions on the idea that promoted land uses enhance multiple ecosystem services. In many cases, more evidence is needed to credibly link land management such as reduced grazing in páramo grasslands to desired outcomes such as improved base flow in focal locations and at the targeted scales. Likewise, while a large number of funds have run ecosystem service models, few utilized these results in a formal investment prioritization, and none reported characterizing the uncertainty in model outputs. This was partially due to pre-existing prioritization mechanisms (e.g., the Forest Code in Brazil or critical areas determined by the Quito water company), but also because of the challenge of translating model results into practice, given constraints including security, landowner preferences, and accessibility. For prioritization efforts to work on the ground, they must be able to account for and incorporate socio-economic, and political opportunities and constraints alongside biophysical processes (Ruckelshaus et al., 2015).

The majority of water funds surveyed have had activities on the ground for fewer than 5 years, an inadequate duration over which to evaluate the impacts, particularly those related to water quality and quantity objectives. Many of the measures of success that water fund managers and the broader ecosystem services community await regarding the success of water funds in maintaining and/or improving water quality and quantity are not yet available. FONAG and Extrema, the two programs with nearly 10 years of activities on the ground, have conducted short-term studies demonstrating positive impacts on terrestrial ecosystem integrity and water quality at the site scale (Enclada et al., 2014; Piccirelli and Barbosa, 2014). However, research into water impacts at larger scales will remain a long-term need, closely linked to the continued expansion of monitoring efforts.

The observation that the majority of water funds with activities on the ground had already established some type of monitoring

program, and others were in planning stages, is a favorable finding. The LAWFP and other such groups have strongly emphasized monitoring in recent years, including supporting the publication of monitoring guidance specifically around water funds (Higgins and Zimmerling, 2013). Yet many programs face constraints such as the technical and financial capacity to design robust monitoring schemes or to conduct analyses of results, a paucity of existing baseline data, and difficulties in finding appropriate control sites. Despite these challenges, program representatives articulated how monitoring of ecological and socio-economic impacts aligned with program objectives at multiple scales was critical to ensuring efficient investments as well as the continuation or expansion of financial and political support.

The attribution of changes in ecosystem services, biodiversity, or social outcomes to water fund activities remains a particularly strong challenge (Porras et al., 2013). Demonstrating that current or future conditions with a water fund are preferable to the absence of the water fund remains a challenge as it does for PES and conservation programs more broadly (Ferraro and Pattanayak, 2006; Porras et al., 2008; Ferraro et al., 2012). This is compounded by the scarcity of well-organized and coordinated baseline data in the regions where water funds may have the most appeal. While baseline data from water companies and government agencies existed in some areas, access to time series of stream flow and data on nutrients, pathogens, and sediments was mostly inadequate for assessment needs.

Acknowledging these challenges, we put forward several recommendations that will help water funds more accurately demonstrate the impact of their activities and adaptively manage to reach their objectives. First, water funds should be clear on what the funds are expected to deliver, at what spatial scale, and monitor accordingly. However, this must be balanced with the areal extent of conservation activities on the ground (e.g., the conservation “footprint” might be small enough to merit monitoring only at the site scale). Second, monitoring should include an experimental design in which the fund can compare areas with conservation activities to areas without. Likewise, monitoring should be initiated as early as possible in the water fund planning schedule, in accordance with the experimental design, rather than waiting until program activities have begun. Third, water funds should have a dedicated data collection and analysis team and agree upon indicators that will be used to report back to stakeholders and adaptively manage. Finally, water funds should explore methods to address data scarcity, including creating data sharing agreements as a routine part of water fund legal agreements. Though perhaps insufficient to provide a long enough baseline for the most robust analyses of change, some pre-intervention data are likely preferable to none.

4.3. *Greater attention to biodiversity and socio-economic monitoring, in addition to hydrologic monitoring, could increase the ability of water funds to achieve objectives*

Echoing concerns raised previously (Bennett and Carrol, 2014; Richards and Mwampamba, 2013), we found relatively low levels of socio-economic monitoring, both in terms of ‘upstream’ and ‘downstream’ impacts. We see this as potentially troubling both from an equity perspective and a sustainability perspective, as monitoring is critical to understanding how participants perceive benefits, costs, and risks of participation. However, of note is the recent IDB-GEF project activity to support ‘upstream’ social protocol monitoring in 5 additional funds (increasing the number of funds monitoring socio-economic impacts to 9), which should improve this situation substantially. Several baseline assessments, and a social impact assessment (Rodríguez, 2014; Benites, 2015; Gammie et al. (In Preparation)) have already been conducted along

with pilot socio-economic assessment in FAVS. The pilot FAVS (Rodríguez 2014) monitoring found that the majority of landowner participants in the water fund perceive participation positively and report benefits in terms of improved production and land value. This socio-economic monitoring program and others will be expanded and should allow for a more effective assessment of socio-economic impacts over the next 5–10 years. In addition to demonstrating success, these monitoring and social impact assessment efforts aim to enable water funds to adaptively manage and better meet both social and ecological goals. Given the time lag of downstream ecosystem service response on larger watershed scales, some types of ‘upstream’ social impacts may be among the first benefits observed, along with improved watershed governance among multiple stakeholders. Likewise, quantifying the value of ecosystem services for downstream beneficiaries is of critical importance for garnering greater support from the public and private sectors (Gartner et al., 2013)

If water funds claim joint benefits for biodiversity, greater attention to monitoring biodiversity outcomes resulting from program activities is warranted. This will require greater investment in monitoring and identification of key indicators and metrics, and monitoring designs and approaches, characteristic of a comprehensive evidence-based approach (Reyers et al., 2012). However, while water funds may provide important biodiversity benefits, it should be noted that, through their primary focus on ecosystem service objectives, targeting and outcomes will likely vary from what would be the case if biodiversity was the primary objective (Reyers et al., 2012). Claiming biodiversity co-benefits, accordingly, depends upon demonstrating biodiversity benefits, ecosystem service benefits and also that additional resources for biodiversity conservation are available because of the focus on ecosystem services.

4.4. *Water Funds obtain funding from diverse sources, but public sector funding dominates. Support from the for-profit private sector is growing but remains limited*

Despite the potential support from the for-profit private sector (Gartner et al., 2013; Bennett and Carrol, 2014), investment in water funds in Latin America came primarily from water utilities and other public sector entities. However, notable examples of for-profit private sector involvement included the sugarcane sector in FAVS (Valle de Cauca, Colombia), a range of private industry in Monterrey, an investment by Coca-Cola and its bottlers (FEMSA, ARCA and BEPENZA) in a groundwater replenishment project across multiple countries, and the participation of other representatives of the beverage industry such as some SAB-Miller subsidiaries, ABI-AMBEV and Pepsico. In general, water funds created after the formation of the LAWFP have attracted more private funding than older water funds given that the LAWFP encourages public-private partnership agreements. Moreover, all water funds but one have received some form of NGO or multi-lateral agency support, which highlights the importance of civil society and multilateral agencies, particularly in providing seed funding.

4.5. *Legislation or some other public policy, rather than endowment or trust funds, has been the most effective mechanism for long-term, guaranteed funding*

In general, we found three major models of program funding, with different degrees of long-term sustainability (Table 3). At the time of the survey, the most prominent model by far was the voluntary contribution model, whereby Board members voluntarily contributed a given amount of money on an annual or multi-annual basis. This was the case for all funds but four, including

FONAG, Extrema (within the São Paulo fund), Espírito Santo, and FONAPA, which have secured (or were about to secure) long-term funding through legislation. Despite the prevalence of voluntary contributions, programs backed by some legal structure gathered more resources. The trust fund model occurred alongside both fully voluntary, and hybrid voluntary-legislative mechanisms. A major feature and highlighted strength of the water fund model has been its potential for sustainable and secured financing primarily through an endowment or trust fund model (Benítez et al., 2010; Calvache et al., 2012; Goldman-Benner et al., 2013, 2012). However, our finding that the most prominent model for durable funding was via some legal structure suggests that the endowment or trust fund model is just one approach to long-term funding. Even in the case of FONAG, which was the first fund established, increasing the value of the endowment rested upon policies which ensured long-term financial contribution from the water company (Echavarría et al., 2004). Accordingly, where opportunities exist to grow an endowment, combining legislation, endowments, and voluntary contributions as a hybrid model may provide the greatest security and transparency of funding sources for the long-term.

4.6. *Water funds bringing together major water users, NGOs, government, and upstream communities/land stewards have been most successful in obtaining funding and implementing activities*

Water funds have been characterized by their potential to bring together multiple water users and other stakeholders in a single governance body that decides how and where resources are used (Goldman-Benner et al., 2013, 2012; Raes et al., 2012; Kauffman, 2014). Our findings support the idea that water funds can convene diverse actors, underscoring how enhanced governance may be an important benefit of these programs. Our results suggest that gaining support of the major water user (e.g., a water utility in urban areas, and large-scale agriculture in zones like the Cauca Valley) is critical for a viable fund. The two water funds that have not yet done this are slower to move forward with activity implementation. Institutions vary in their willingness to participate in such initiatives, with some public water utilities eager to invest voluntarily in watershed activities (e.g., EMASA in Camboriú, EPM in Medellín, and CAESB in Brasília), while others will likely require a legal mechanism to catalyze participation.

However, our results point to limited current participation of the private sector and of upstream communities and land stewards. With the exception of FAVS and the sugarcane sector, the Monterrey fund, and widespread participation of the beverage industry across the LAWFP, there remains notably limited private sector participation in water funds. However, awareness is rising of the need for corporations to engage in watershed approaches that manage water risks and empower solutions beyond the boundaries of their operations (WBCSD, 2014). We see great opportunities to increase private sector investment linked to water risk and interest in offsetting water use through conservation and restoration. A good example of this is the Coca-Cola Replenishment project in which Coca-Cola and bottlers will be investing \$6 million in water use offset projects associated with water funds. Other companies, including PepsiCo, are pursuing similar types of programs. While these initiatives do not involve privatization of water rights or access, water funds will need to be aware of concerns about private sector involvement. Particularly in regions such as the Andes, where multiple water funds are underway, communities and governments have actively resisted payments for ecosystem services for the potential risks and negative impacts of privatization and/or private sector involvement in terms of use and access rights for local communities and municipalities (Kauffman, 2014; Reed, 2011). Kauffman (2014) documents how

water funds in Ecuador responded to these concerns by creating participatory institutional structures, which increased stakeholder trust and support. Similarly, for community-based river associations that have worked with communities for over 20 years, active participation in FAVS (with primarily private sector funding) has likely improved stakeholder support of this program.

We also find low inclusion of ‘upstream’ land stewards on Boards and PMUs. The two funds with upstream representation (FAVS and Tungurahua) are among the most established and successful funds in terms of the number of participating land stewards (Supplementary material 2). This suggests that greater involvement of upstream actors, which also increases “equity in decision making” (Brown and Corbera, 2003), could strengthen water fund capacity to work effectively with local communities and land stewards (Kauffman, 2014).

4.7. Multiple replicable models for project implementation exist, with outsourcing to a third party currently the most common, but the grant model and hybrid approaches appear promising

We identified three non-exclusive models by which water funds implemented Board or PMU decisions. The *outsource* model – by far the most dominant—where water funds contract out planned activities to a third party; the *agency* model, where water funds implement activities themselves; and the *grant* model where water funds review proposals by governments, NGOs, and community groups. The difference between the *outsource* and the *grant* model relates to who designs the plans: in the *grant* model, the water fund approved and selected among proposals, while in the *outsource* model, the water fund defined the projects, but contracted out their implementation. However, we found that the line between the *outsource* and *grant* models was often thin as *outsourcing* often involved close collaboration with communities/landowners and *grants* were often selectively reviewed and implemented in line with the broader water fund work plan approved by the board.

We identified four funds who used the grant model as part of their strategy (Tungurahua, Guandu, FONAPA, and FAVS). In Tungurahua, for example, the water fund funds management plans of communities – implemented by communities or collaborating NGOs. As noted by Kauffman (2014) in his assessment of water funds in Ecuador, this model builds on existing social capital of NGOs and community organizations, which have often worked for decades to build trust and capacity among communities. While the *outsource* model also will often build off of existing social capital in watersheds (working with local partners), the *grant* model may allow for more active engagement in planning and decision making by partners. Although this may make watershed planning more difficult in some ways (e.g. the Board or PMU may not be able to implement their ‘ideal’ plan), we argue that the *grant* model, where it can fit into an overarching broad watershed plan, may be more sustainable over the long term as partners actively own projects. This model has great potential for scale in areas where NGOs, community groups, and government organizations have established capacity and relationships with upstream communities and land stewards and where these organizations are well equipped to engage in watershed planning.

It was also common for programs to combine implementation approaches. For example, the *outsource* model is common in Brazilian programs, where NGOs, like Instituto Terra in Guandu, carry out restoration activities on private lands. However, The Guandu fund recently started a new initiative calling for proposals from municipalities and yielding a hybrid between the *grant* model and *outsource* model. In another example, in FONAG, the water fund itself carried out the activities (the *agency* model), through, for example, hiring páramo park guards as official FONAG staff.

However, FONAG also contracts out some work (*outsource*) and also receives proposals from NGOs and communities (*grant*), demonstrating that water funds may productively follow multiple implementation models. To follow the agency model, water funds must have substantial technical and human resources, suggesting the other two models may be more viable for beginning programs and easier to scale where third parties with sufficient capabilities and capacities exist. Moreover, although often overlooked, socio-economic conditions, including trust between landowners and program operators are key for program success and can take years to establish (Bremer et al., 2014a; Southgate and Wunder, 2009; Wunder, 2013).

4.8. Water funds promote a mixture of protection, restoration, and sustainable agricultural activities to achieve their goals. While the link between some types of activities and project goals are clear, in other cases the link is based on assumptions and needs re-examination

As with many other IWS programs (Farley et al., 2011; Martin-Ortega et al., 2013; Porras et al., 2013; Southgate and Wunder, 2009), water funds generally promoted protection and restoration of native ecosystems for multiple ecosystem services. A number also promoted sustainable agriculture and grazing practices for joint livelihood and ecosystem service goals. Water funds generally promoted these land uses and management practices assuming a positive relationship between vegetation cover and targeted hydrologic ecosystem services (Porras et al., 2013). While the evidence is strong that conserving and restoring native forest can improve water quality (Brauman et al., 2007; Bruijnzeel, 2004; Ogden and Stallard, 2013), evidence for the link between restored forest and sub-annual water yield is poorly understood, particularly in tropical regions where water funds are growing (Brauman et al., 2007; Ponette-Gonzalez et al., 2014). Likewise, while there is support for the idea that protection of páramo grasslands from heavy overgrazing, afforestation with exotic species, and agricultural conversion maintains hydrologic regulation (Buytaert et al., 2006, 2005, 2002; Farley et al., 2004), understanding of the effects of restoration strategies remains scarce (Harden et al., 2013). Limited evidence of the impacts of land management on hydrologic regulation is of concern given the primacy of this objective in many water funds. Such limitations also result in a lack of quantitative relationships among goals for activity implementation and hydrologic regulation outcomes. These shortcomings point to the importance of research and monitoring efforts to understand the links between land management, including forest and grassland conservation and restoration as well as working lands management and hydrological regulation.

4.9. Water funds appear to have successfully engaged rural land stewards, but greater participation of upstream communities is needed on Boards and PMUs

All water funds worked extensively with local land stewards, either directly or through third party partners (depending on the model employed) and used PES contracts, in-kind compensation agreements, or a combination of both. How funds work with land stewards and the choice of compensation mechanism (cash payments or in-kind compensation) was driven by the goals, funders, and socio-political context. Within this context, we find three basic models based on the type and nature of the compensation, including 1) *payments as a carrot*, 2) *integrated sustainable livelihoods and conservation*, and 3) *land purchase* (Table 2). In the first case, particularly prominent in Brazil in relationship to the Forest Code, PES payments were seen as ‘a carrot’ to complement the ‘stick’ of regulation (Engel et al., 2008; Goldman-Benner et al.,

2013). In the Andes, however, there has been resistance to cash payments (Reed, 2011; Kauffman, 2014) and potential links to privatization, and also a paucity of policy mechanisms for water funds to utilize cash payments. Thus, in the majority of the Andean funds, as well as the emerging Dominican Republic funds, the focus was on in-kind compensation, often focused on training and capacity building related to the development of alternative livelihoods sought for their direct environmental and development benefits, but also as a means to ensure the sustainability of conservation and restoration initiatives. In the examples thus far, we found fewer examples that combine supporting diversified livelihoods with cash payments, but this is not to say this combination is not possible.

Finally, one water fund (FONAG) and likely also FONAPA, in the near future, work on land purchased by the water company as one of their strategies. In both of these cases water funds engaged (or will engage) the local community through working with a community-based park guard program. Likewise some programs created jobs related to conservation or restoration activities, which represents a promising social benefit that also contributes to program sustainability. We see great potential for water funds and similar programs to contribute to the local economy in this way as the programs go to scale (Turpie et al., 2008)

An important way that water funds will be able to scale up is through building on existing social and human capital (Kauffman, 2014). As with other conservation and development initiatives, working with local landowners or communities often builds on many years of trust and capacity building by local NGOs, governments, or community organizations (Bremer et al., 2014a). We argue that, in addition to securing financial resources, water funds must continue to seek ways to actively engage local NGOs, community organizations, and municipalities. The *grant* model – which most directly and substantively involves these entities in the implementation of conservation activities, as well as greater effort in including these groups – particularly community organizations-on Boards and PMUs are mechanisms for achieving this. While participation of NGOs on Boards and PMUs are common, participation by community organizations are limited and should be increased.

Conclusions and policy recommendations

While all water funds aim to restore or protect hydrologic ecosystem services, we find significant heterogeneity in water fund objectives, finance and governance mechanisms, the types of activities and landscapes where they are implemented, and the extent of monitoring for ecological and social impacts. Diverse socio-economic, biophysical, political, and cultural contexts require flexibility when designing and implementing water funds and similar programs of investment in watershed services. Successful future water fund development should reflect particular human and natural conditions rather than a “one-size-fits all” approach. Thus far, public funding guaranteed through legislation and institutional structures, which include major watershed stakeholders, has been the most effective strategy in terms of mobilizing financial resources for water funds. As water funds continue to grow and enlarge their private funding base, the critical role of public funding and multi-stakeholder representativeness should not be overlooked. Likewise, active participation by local communities and landowners is critical, at least in some contexts, in engaging, maintaining, and scaling public and community support.

Replication, expansion and sustainability of the water fund model will likely require greater participation from the private sector, legislation to better secure public support, and greater inclusion of upstream land stewards on governance boards.

Likewise, greater support for and coordination of multi-scale impact monitoring for achievement of water fund objectives remains critical for ensuring efficient and equitable investments. Clear demonstrations of multiple benefits to ecosystems and people are essential for continued political and financial support and the expansion of natural-infrastructure approaches to water management. Additional resources need to be directed towards monitoring and evaluating the progress of water funds towards achieving hydrologic and socio-economic goals, and for using this information to adaptively manage. Without a concerted effort in this regard, documenting the effectiveness and cost-effectiveness of water funds as a tool for providing key ecosystem services will remain challenging, hampering the scaling of this promising tool.

Acknowledgments

This research was funded in part by the Gordon and Betty Moore Foundation grant #2996, The Nature Conservancy's NatureNet research fellowship program, and an anonymous private foundation. We thank global, regional, and country staff of TNC and the LAWFP, including Paulo Petry, Maria Claudia de la Ossa, Liliana Martinez, Carolina Polania, Lina Gallego, Jaime Camacho, Andrea Salcedo, Aldo Cardenas, Luis Alberto Gonzalez, José Aquino Machado, Hendrik Mansur, Samuel Barreto, Henrique Bracale, Cristina de la Paz, Myles Coker, Victor Guevara, Malki Saenz, Santiago Rodriguez, Oscar Rojas, and Whitney Hank for their help with the survey and Gretchen Daily and Rebecca Chaplin-Kramer for comments on the manuscript. We also thank two anonymous reviewers for their useful and insightful comments and suggestions.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.ecoser.2015.12.006>.

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